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ENCOURAGING THE APPROPRIATE USE OF HIGH BEAM HEADLAMPS: AN APPLICATION OF THE THEORY OF PLANNED BEHAVIOR

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ENCOURAGING THE APPROPRIATE USE OF HIGH BEAM HEADLAMPS:
AN APPLICATION OF THE THEORY OF PLANNED BEHAVIOR

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ABSTRACT

Drivers typically underuse their high beam headlamps at night even under ideal conditions (i.e., no leading, following, or oncoming vehicles). One explanation for this is a lack of knowledge regarding both the magnitude of visibility problems at night and the benefits that high beams provide. The purpose of the present study was to design and evaluate an educational intervention based on the Theory of Planned Behavior (TPB) that targeted a more appropriate reliance on high beams. The results of Study 1 indicated that attitudes toward high beams best predicted intentions to use high beams. This information informed the design of an intervention delivered and evaluated in Study 2. TPB components accounted for 41% of the variance in intentions to use high beams and 38% of the variance in high beam usage. The educational intervention and implementation intentions did not significantly increase drivers' use of high beams. Future research should continue to investigate predictors of high beam use and additional ways in which drivers can be encouraged to use their high beams appropriately.

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INTRODUCTION

In 2012 in the United States, over 4,700 pedestrians were killed in traffic collisions and almost 70% of these fatalities occurred at night. Pedestrians' increased risk of involvement in traffic collisions at night is due in large part to the low illumination conditions associated with night driving. Indeed, analyses of the U.S. Fatal Accident Reporting System (FARS) crash database revealed that as ambient illumination decreases, pedestrian fatalities increase even when other crash factors such as alcohol consumption and driver fatigue are held constant (Owens & Sivak, 1996; Sullivan & Flannagan, 2002). Sivak, Schoettle, and Tsimhoni (2007) reported that pedestrian fatality rates increase by over 20% on nights with a new moon (i.e., 0% illumination) relative to nights with a full moon (i.e., 100% illumination), confirming that ambient illumination plays a critical role in pedestrian fatalities. Compounding this problem is the fact that many drivers overdrive their headlamps at night (i.e., driving at unsafe speeds given reduced illumination), since low beam headlamps provide insufficient illumination to ensure that drivers will be able to see and respond to hazards in time to avoid collisions (Sullivan & Flannagan, 2001). Leibowitz, Owens, and Tyrrell (1998) reported that when drivers relied on low beam headlamps while driving 25 mph, the stopping distance required to avoid a collision with a pedestrian wearing dark clothing was 1-3x greater than the visibility distance of that pedestrian. This finding suggests that drivers' reliance on low beam headlamps contributes to the increased risk of pedestrian fatalities at night, as recognizing pedestrians under low illumination conditions is particularly difficult for drivers.

The first purpose of the present study was to examine the factors influencing drivers' under-reliance on high beam headlamps; this information was used to design an educational intervention to address the underuse of high beams. Specifically, the intervention provided drivers with information aimed at increasing their use of high beams and understanding of the visual challenges they face when driving at night. A review of existing literature will first discuss the benefits of high beams and data concerning their underuse by typical drivers. Next, the applicability of educational interventions to solving this problem will be discussed; specifically, the Theory of Planned Behavior will be introduced as a framework for both developing and evaluating interventions designed to change behavior. The utility of including implementation intentions in such interventions will be introduced. Finally, the two present studies will be presented.

Substantial research (e.g., Balk, Tyrrell, Brooks, & Carpenter, 2008; Wood, Tyrrell, & Carberry, 2005) has demonstrated that pedestrians' conspicuity to drivers at night can be enhanced by the use of retroreflective material. Allen, Hazlett, Tacker, & Graham (1969) were among the earliest to discover that placing retroreflective material on a pedestrian's extremities (e.g., arms, legs, ankles) greatly enhances the distance at which drivers are able to recognize that pedestrian. They found that a pedestrian who wore a jacket with retroreflective material on the sleeves and collar was resulted in the longest recognition distances of three configurations they tested, while a pedestrian wearing black clothing was recognized at the shortest distance. Similarly, Shinar (1984) reported that the mean visibility distance for a pedestrian wearing a retroreflective tag was nearly double that of a black-clad pedestrian. More recent research has focused on the conspicuity benefit of the biological motion (biomotion) configuration. The first study (Owens, Antonoff, & Francis, 1994) to do so was a video-based study that reported that the biomotion configuration of retroreflective material resulted in participants responding with significantly longer time-to-impact values. Later, a closed-road study (Wood, Tyrrell, & Carberry, 2005) found that drivers' recognition distance of a pedestrian wearing retroreflective material in the biomotion configuration (i.e., retroreflective markings on the wrists, elbows, shoulders, waist, knees, and ankles) was up to 50x greater than other clothing configurations even compared to a configuration that used an equivalent amount of reflective material that was positioned on the torso. Recognition of the biomotion configuration was also found to be robust to the detrimental effect of simulated headlight glare from an oncoming vehicle. Research (e.g., Balk, Tyrrell, Brooks, & Carpenter, 2008) also indicates that the advantage of biomotion still exists even when fewer body parts are marked. The results of this study were that an ankles and wrists configuration resulted in recognition distances that were not significantly different from the full biomotion configuration when the total surface area of retroreflective material was matched for both conditions. This finding indicates that a configuration that may be more convenient for pedestrians to implement provides the same conspicuity benefits as the perhaps less feasible biomotion configuration.

While the addition of retroreflective material to pedestrians' clothing provides an effective and potentially simple means by which to improve pedestrian conspicuity at night, the usefulness of retroreflective material is dependent on illumination from headlamps. High beams are designed to project greater illumination on the roadway, including onto the roadway that is farther ahead of the vehicle (Rumar, 2000). High beam headlamps afford substantial visibility benefits due to the aim of the beams as well as increased illumination projected on the roadway and they provide substantial safety benefits to drivers (Helmers & Rumar, 1975).

Previous research (e.g., Olson & Sivak, 1983; Roper & Howard, 1937; Wood, Tyrrell, & Carberry, 2005) has documented the limitations of low beam headlamps and the increased visibility afforded by high beam headlamps. Roper and Howard (1937) first reported that as the candlepower of headlamps decreased, visibility distance systematically decreased. Furthermore, they found that decreased candlepower combined with low contrast clothing on pedestrians led to drastic decreases in drivers' ability to detect pedestrians, indicating that both pedestrians' clothing and headlamp illumination are both factors influencing conspicuity. Olson and Sivak (1983) provide further support for this conclusion. Visibility distances for a dark-clad pedestrian were compared with stopping distances, revealing that visibility distance was often shorter than stopping distance when drivers used low beams. Olson and Sivak concluded that low beam headlamps do not provide sufficient illumination for drivers to recognize dark-clad pedestrians at night with enough time to avoid a collision. Switching from low beams to high beams can greatly improve the likelihood that a driver is able recognize a pedestrian at night. Shinar (1984) also reported that visibility distance is increased by a substantial margin when drivers use low beams instead of high beams. More recently, Wood, Tyrrell, and Carberry (2005) reported that mean recognition distance of a pedestrian increased by a factor of 1.6x on average when drivers used high beams. High beams were particularly useful for the clothing conditions that did not include retroreflective material, as response distances increased, on average, by a factor of 2.7x.

Despite the fact that high beam headlamps improve drivers' ability to see at night, drivers typically underuse this beam setting. Hare and Hemion (1968) were the first to measure real world beam usage. They were specifically interested in how often drivers used high beams under the worst visibility conditions (i.e., two lane unlit rural roadways). Their observations of beam usage under these conditions indicated that drivers used high beams less than 25% of the time even when the use of high beams would have improved their visibility without impairing the vision of oncoming drivers. Several more recent studies have confirmed the finding that drivers underuse their high beams. Sullivan, Adachi, Mefford, and Flannagan (2004) observed beam usage on two lane, rural roadways with no fixed illumination present and judged only "clear vehicles" (i.e., no opposing, leading, or following vehicles present). Judgments of these vehicles indicated that high beams were only used half of the time, despite drivers being presented with ideal conditions for high beam usage.

Both Mefford, Flannagan, and Bogard (2006) and Buonarosa, Sayer, and Flannagan (2008) measured beam usage by drivers who were asked to drive instrumented vehicles for 7-27 days. Mefford et al. reported that 21% of the miles driven took place at night and during that time high beams were use only 3% of the time. Furthermore, even under ideal conditions (rural roads; no opposing or leading vehicle) drivers' high beam usage did not exceed 25%.

The reasons that drivers underuse their high beam headlamps are not clear. One possibility is that drivers are reluctant to present headlight glare to oncoming vehicles, believing that their headlights may impair other drivers' ability to see. Singh and Perel (2003) conducted survey research on behalf of the National Highway Traffic Safety Administration (NHTSA) and found that approximately 30% of drivers reported that glare from the headlights of oncoming vehicles had been 'disturbing' to them. Drivers' discomfort in the presence of headlight glare may lead them to believe that they are visually impaired as well. Many drivers may avoid the use of their high beams in order to prevent the occurrence of glare to other drivers. However, in assuming that high beams disable other drivers, drivers may fail to distinguish between disability and discomfort glare. In the present context, disability glare occurs in one of two ways: one is when the visual system is exposed to sudden changes in luminance, causing a loss of dark adaptation by the visual system (Mainster & Turner, 2012); the other is when light from an oncoming vehicle scatters in the eye, creating a luminous veil that decreases the contrast of objects on the retina and thus reducing drivers' ability to detect these objects. Discomfort glare is the subjective feeling of annoyance and/or pain that can be associated with exposure to glare. Drivers are acutely aware of their subjective experiences with glare (i.e., discomfort glare) but may not accurately appreciate the extent to which their visual abilities are affected by glare (i.e., disability glare).

While there is some evidence (e.g., Balk & Tyrrell, 2011; Flannagan, Sivak, Traube, & Kojima; Whetsel, 2011) that drivers do not fully understand the effect of headlamp glare on vision, it is likely that this is not the only reason drivers fail to use their high beam headlamps under ideal conditions. Hare and Hemion (1968) suggested that another reason for the underuse of high beams is drivers' "ignorance of the visibility improvement obtainable with use of high beam" (p. 22). If drivers are unaware that high beam headlamps provide more illumination than low beams and therefore greater visibility, they are unlikely to use this tool. The selective degradation theory put forth by Leibowitz and his colleagues provides a framework for understanding why drivers may be unaware of the need for high beams. There are two neural streams upon which our visual system relies. Ambient vision (Goodale & Milner, 1992) facilitates our ability to navigate the roadway and is robust even under conditions of low luminance (i.e., night). Focal vision (Goodale & Milner, 1992), which supports our ability to recognize objects, is selectively degraded under these same conditions thus limiting recognition of objects in the environment. Leibowitz & Owens (1977) hypothesized that drivers are overconfident in their visual abilities when driving at night because the robustness of their ambient vision prevents them from being aware of the selective degradation of their focal vision; drivers appear not to understand the magnitude of the debilitating effect of low illumination on their ability to see low contrast objects on or along the roadway (Brooks, Tyrrell, Wood, Stephens, & Stavrou, 2005). The fact that commonly encountered roadway objects (e.g., retroreflective signage, retroreflective lane delineators, vehicle marker lights) have been engineered to have a high level of contrast may provide further support for drivers' misconception that their low beam headlamps adequately compensate for any visual challenges that result from reduced ambient illumination (Leibowitz, Owens, & Tyrrell, 1998). Thus drivers who do not fully recognize the visual challenges they face at night, and appear to believe that their low beam headlights are adequate for enhancing vision at night, may be less likely to use their high beams.

Lending support to this hypothesis is a finding reported by Tyrrell, Patton, and Brooks (2004). Participants in that study who did not receive a relevant lecture estimated recognition distances under high beam illumination (171 m) to be barely longer than low beam illumination (162 m). This finding suggests that road users do not appear to understand the magnitude of the benefit of high beam illumination on their conspicuity. Tyrrell et al. postulated that drivers, like pedestrians, may fail to appreciate the conspicuity enhancing benefits of high beams.

There is evidence to suggest that education about the challenges drivers face when driving at night can lead to a change in young adults' misconceptions about pedestrian safety and conspicuity at night. Tyrrell, Patton, and Brooks conducted two studies, the first of which involved participants from an introductory psychology class receiving an educational lecture about the visual challenges associated with night driving, as well as the problem of pedestrian visibility at night. Several weeks after receiving the lecture, participants were asked to estimate their own visibility under two beam settings (low and high beams) and three clothing conditions (black, white, and biological motion). The participants who had heard the lecture about night driving estimated, on average, significantly shorter recognition distances relative to participants from the control group who had not heard the lecture.

For their second experiment, Tyrrell et al. recruited high school students enrolled in a driver's education course. Half of the students heard a lecture that was intended to educate the students about the dangers associated with driving at night. The other half did not receive this lecture. As in Experiment 1, participants later provided estimates of their own visibility at night. Participants in the lecture group estimated shorter visibility distances than those in the control group, demonstrating a 56% decrease in overall estimated visibility distance. Taken together with Experiment 1, these findings demonstrate that an educational intervention can be a means by which pedestrians' judgments of their own conspicuity are effectively modified.

In a more recent study, Balk, Brooks, Klein, and Grygier (2012) confirm the findings presented by Tyrrell et al. In this study, university students were recruited from introductory psychology classes, one of which had heard a lecture on nighttime driving and one had not. Participants were recruited to participate in the study at least two weeks after hearing the lecture. They were asked to imagine themselves wearing one of four clothing conditions (black; black clothing with a retroreflective chest tag; biomotion; white) and to indicate the point at which they estimated a driver would recognize them as a pedestrian at night. This task was computer-based, as participants scrolled through a series of daytime photographs of a vehicle at different distances (range of 10 to 1280 ft.) and selected the photograph that represented the distance at which a driver would just be able to recognize that a pedestrian were present. This task was completed eight times: twice for each clothing configuration, once imagining the driver using low beams and once using high beams. There was a marginally significant (p = .07) difference between estimates from the control and lecture groups, with the lecture group estimating shorter recognition distances (M = 55.7 m), on average, relative to the control group (M = 66.5

m). Again, these findings indicate that education may help pedestrians and drivers to better understand the problem of pedestrian conspicuity at night.

While the fact that educational interventions have the potential to lead to changes in attitudes and/or behaviors is of practical value, the process by which attitudes and behaviors that are relevant to night driving are changed has not been explored. The Theory of Planned Behavior (TPB; Ajzen, 1985) provides a framework for understanding how interventions may lead to changes in intentions and/or behavior; see Figure 1. The TPB is based on the theory of reasoned action, which assumes that intention to perform a behavior determines the likelihood that action is taken to complete the behavior. Intentions are thought to be a function of attitude toward the behavior and subjective norm (i.e., perceived social pressure to perform the behavior). The TPB is slightly different in that it postulates that intentions are predicted not only attitude toward the behavior and subjective norms, but also by an individual's perceived control over the performance of the behavior (i.e., perceived behavioral control). According to the TPB, a favorable attitude and perception of subjective norms along with elevated perceived behavior control often leads to greater intention to perform a behavior. Intention and perceived behavioral control are considered to be the only proximal determinants of actual behavior (Ajzen, 1991). There is some evidence (e.g., Bentler & Speckart, 1979) to suggest that previous performance of a behavior influences the performance of the behavior at a later time, independent of the three predictors of intention to complete the behavior. However, Ajzen (1985) states that past performance of a behavior should have no independent influence on present behavior so long as the person has complete control over the behavior.

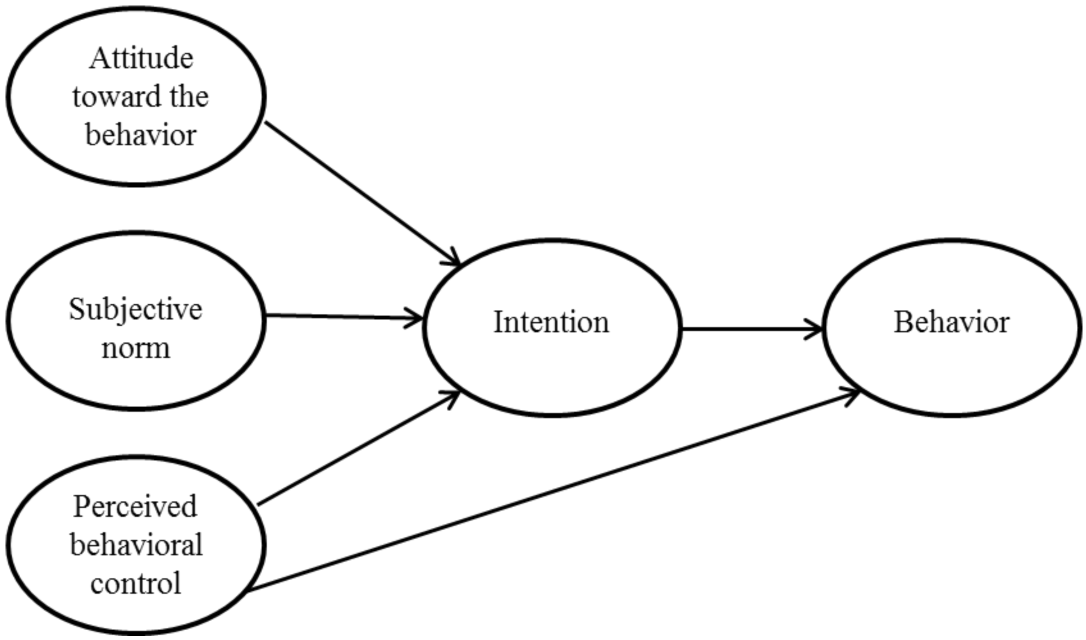

Figure 1. The theory of planned behavior.

There is evidence demonstrating the efficacy of the TPB in predicting and understanding intentions and behaviors in a wide variety of contexts. Armitage and Conner (2001) conducted a meta-analysis of 185 studies that utilized the TPB. The results of this analysis indicated that the TPB is useful for the prediction of both intentions and behavior. Intention and perceived behavioral control (PBC) together were strongly correlated (r = .52) with behavior; PBC was also a unique predictor of behavior. Finally, intention appears to be a strong predictor of behavior (r = .47). Intention and PBC are, however, more strongly correlated with self-reports of behavior than with objective measures of behavior (Armitage & Conner). Finally, subjective norms was shown to be only weakly related to intentions, though this may be due to the fact that many studies often use only single-item measures of subjective norm. Armitage and Conner concluded that although the TPB's predictive power is stronger for self-reports of behavior, it still accounts for 20% of variance in objective measures of behavior, suggesting that the TPB is a useful tool for predicting intentions and behavior in a variety of domains (e.g., treatment seeking, organ donation, driving safety). A few examples of applications of the TPB follow.

Britt et al. (2011) used the TPB to predict whether veterans seek treatment for psychological problems, specifically organizing previously researched factors (e.g., perceived stigma, barriers to treatment, and beliefs that one can handle their own problems) influencing treatment seeking. Britt et al. hypothesized that perceived stigma and veterans' beliefs about their own problems would be antecedents to attitude toward seeking treatment, while barriers to care would influence perceived control. The authors further speculated that the three TPB components would predict treatment for psychological problems; intention was not included in the study as it could not be assessed. Over 700 members of the National Guard and Reserve from the Army, Marine, and Air Force were surveyed for this study. The questionnaire included measures of treatment seeking, perceived stigma, barriers to care, and views of psychological problems in addition to measurement of the TPB components. Using data from only veterans who reported having a psychological problem, Britt et al. examined the factors that predicted treatment seeking behavior. Overall attitude toward treatment was a significant predictor of treatment seeking; however, neither subjective norm nor perceived control accounted for unique variance in treatment seeking. Britt et al. stated that the TPB was useful in identifying treatment seeking veterans primarily based on their attitudes toward treatment (e.g., perceived severity of psychological problem). The authors were also able to organize existing determinants of treatment seeking in the TPB framework, identifying the antecedents to attitudes and perceived control.

Rocheleau (2013) conducted a study used to show that the TPB can be an effective tool to predict intentions to engage in organ donation behaviors. The study was completed in two sessions; the first assessed past donation behaviors and gathered data on organ donation attitudes, subjective norms, PBC, and intentions to complete organ donation behaviors. The second session determined if participants had engaged in organ donation behaviors (e.g., participants discussing their organ donation wishes with family members) in the time since the first session. The results of the study indicated that all three of the TPB components were significant predictors of intention to engage in organ donation behaviors. Similarly, intention to engage in these behaviors was a significant predictor of actual behavior. Rocheleau concluded that an understanding of the "proximal predictors" of organ donation intentions may be useful in designing interventions to increase the likelihood of organ donation.

Greaves, Zibarras, and Stride (2013) used the TPB both to develop a questionnaire and to identify predictors of pro-environmental behaviors in the workplace. They developed a TPB-based questionnaire by conducting workshops of small groups of employees in order to identify the behaviors that should be measured in the questionnaire; specifically, the authors sought to determine pro-environmental behaviors employees would engage in in the workplace that would offer significant benefits to the environment. Based on data from the workshops, three pro-behaviors were identified: switching off computers when leaving desk for more than an hour, using video conferencing for distance meetings, and recycling waste. These behaviors formed the basis for scenarios that were used in the TPB questionnaire to determine the best predictors of employees' intentions to complete these behaviors. Over 400 employees were asked to complete the TPB questionnaire. Overall, the TPB constructs accounted for 46-61% of variance in intentions to engage in the pro-environmental workplace behaviors, suggesting that the TPB was useful for predicting employees' intentions. Greaves et al. concluded that the TPB can be useful in helping organizations to understand the factors that may encourage or discourage employees from engaging in pro-environmental behaviors at work.

Like Greaves et al., Zhou, Wu, Rau, and Zhang (2009) used the TPB to guide the development of a questionnaire that was designed to predict young drivers' intentions to use a phone while driving. Zhou et al. used a questionnaire that included measurements of all three TPB components, intentions to use a cell phone while driving, and perception of risk associated with this behavior. The results of the study indicated that the TPB variables accounted for 42% of the variance in intentions to use a hands-free cell phone and 58% of the variance in intentions to use a handheld cell phone, with all three TPB components being significant predictors of both intentions. Zhou et al. concluded that the TPB was useful in predicting drivers' intentions to use either a handheld or hands-free cell phone. Unfortunately, measures of the relevant behavior (i.e., using a phone while driving) were not included.

Nemme and White (2010) created a TPB-based questionnaire used to predict another safety concern: texting while driving. Participants in this study first completed a questionnaire that included standard measures of the TPB components and then returned a week later to report the number of text messages they sent and read while driving during the time since completing the first questionnaire. Nemme and White found that all three TPB components were significant predictors of intentions to send texts while driving, while only attitude predicted intentions to read texts. The authors also analyzed the utility of the TPB in predicting self-reports of texting behavior and found that only intention (and not PBC) was a significant predictor of sending and reading texts. Nemme and White concluded that the TPB was useful in predicting texting behavior, with attitude being a key factor in predicting young drivers' intentions to text while driving.

The TPB has also been used by researchers to evaluate the efficacy of interventions that are designed to change attitudes or behavior. Poulter and McKenna (2010) conducted two experiments that used the TPB as a framework to assess the effectiveness of an intervention, the goal of which was to effect change in children's attitudes toward dangerous driving. In the first experiment, students watched a video that depicted a crash reconstruction, along with testimonials from individuals directly affected by traffic crashes. The participants completed a questionnaire based on the TPB (with a focus on future intentions) one to two weeks before the intervention, one to two weeks after the intervention, and five months after the intervention. Intentions to drive within the speed limit improved immediately post-intervention but these improvements were not maintained to the five-month mark. The second experiment replicated the first with the exception that a between-participant design was utilized to reduce demand characteristics. The authors found significant, though small, improvements between the control and intervention groups in regards to several outcomes, including intention to drive within the speed limit. Using the TPB, Poulter and McKenna concluded that the intervention used did not successfully target pre-drivers' attitudes and perceived social norms about dangerous driving. Therefore, this intervention did not effect change in this population's intentions to drive more safely. The authors suggested that the TPB should not only be used to measure the effectiveness of an intervention but also to guide the development of an intervention to ensure successful change in intentions and/or behaviors.

Several studies have demonstrated the utility of the TPB in not only evaluating the effectiveness of an intervention but in guiding the development of such interventions. Elliott and Armitage (2009) developed a TPB-based intervention that was designed to change drivers' level of compliance with posted speed limits. Participants assigned to receive the intervention were given an informational booklet that targeted each of the TPB components and that informed participants about the risks associated with speeding. Participants completed baseline and follow-up measures that included (but were not limited to) behavioral beliefs, control beliefs, and intention. Elliott and Armitage reported a statistically significant effect of experimental condition on perceived behavioral control; the intervention did not significantly affect measures of attitude, subjective norm, or intention. Participants who received the intervention reported significantly higher rates of speed limit compliance relative to those reported in the control group. The results of mediator analyses indicated that the effect of experimental condition on self-reported behavior was mediated by changes in participants' perceived behavioral control, suggesting that the intervention successfully changed an important component of speed limit compliance.

Armitage and Talibudeen (2010) created an intervention designed to change attitudes towards and intentions regarding safe sex. The intervention was based on interviews with college age students that allowed the researchers to identify the most salient beliefs about carrying condoms so that these beliefs could be targeted in the intervention. Participants were assigned to either a control intervention condition, which provided information about the history of the condom, or an experimental intervention designed to elicit changes in participants' attitudes, perceived behavioral control, and subjective norms. The intervention failed to change attitudes or PBC, though participants in this condition did report higher levels of perceived social pressure. Additionally, participants who received the experimental intervention had greater intentions to carry condoms than those in the control intervention. Taken together, these findings indicated that intentions to carry condoms were changed largely by changes in perceptions of subjective norm because this TPB component plays the largest role in condom carrying. Armitage and Talibudeen concluded that it may be useful to target only the strongest predictors of intention in an intervention to effectively cause changes in intention.

Parker (2002) was interested in changing drivers' attitudes toward speeding and developed several short video interventions, each of which targeted one component of the TPB as well as anticipated regret (i.e., the negative feelings a driver might experience after engaging in risky behavior). These videos were designed to change the TPB components and intentions to speed while driving. Parker assessed the effectiveness of the videos both qualitatively and quantitatively. In order to qualitatively assess the videos, small groups of drivers (4-8) were assigned to view one of the four videos twice and then provided feedback about the videos. Data gathered from these groups indicated that the videos had the potential to affect drivers' attitudes and beliefs. Participants also indicated that they understood that improving intentions to stop speeding may not translate to actual changes in speeding behavior.

A separate group of participants provided quantitative assessments of the videos via a questionnaire that included measures of the TPB components. A control group also completed this assessment. Participants who viewed the anticipated regret video expressed the most negative attitudes toward speeding. Relative to the control group, all four video groups had lower intentions to speed, though these differences were not significant. Parker concluded that the videos that targeted normative beliefs and anticipated regret seemed to have the most potential to affect attitudes towards speeding. Like Armitage and Talibudeen, Parker suggested that the most effective way to develop communications designed to change attitudes/behavior is to determine the key predictors of these and then use this information to target communications.

Kothe, Mullan, & Butow (2012) used the TPB to develop and evaluate an intervention designed to increase fruit and vegetable consumption. The intervention consisted of a series of automated emails sent over the course of 30 days and was designed to target the three components of the TPB. A pre-post design was used, with participants reporting fruit and vegetable consumption and completing a TPB questionnaire before and after the intervention.

Following the intervention, reports of fruit and vegetable consumption significantly increased. Measures of all three TPB components also significantly increased from baseline to posttest. Kothe et al. also tested the predictive power of the TPB model at baseline as well as post-intervention. At baseline, subjective norm and PBC were significant predictors of intention; intention was a significant predictor of fruit and vegetable consumption. After the intervention, all three TPB components were significant predictors of intention; again, intention was a significant predictor of behavior. The authors concluded that the TPB-based intervention successfully increased fruit and vegetable consumption as well as the three TPB components and intention to consume fruits and vegetables. They point out that the TPB model was more useful in predicting intentions than actual fruit and vegetable consumption, suggesting that the TPB does not account for several variables (e.g., planning, habit) that may bridge the gap between intentions and behavior. Kothe et al. suggest that goal setting may also play a critical role in the success of an intervention.

It is evident that one of the main criticisms of the TPB is that it does not account for the mechanisms by which intentions are translated into actual behavior. Indeed, Efrat and Shoham (2013), who used the TPB to predict intention to engage in aggressive behavior while driving and examined the mediating effect of intentions on actual behavior, found that the TPB was useful in predicting drivers' intentions to drive aggressively but was far less effective in predicting actual aggressive behavior. Efrat and

Shoham point out that the TPB's weakness is in the gap between intentions and behavior and that future research should address "potential intervening factors." Similarly, Britt and McFadden (2012) stated that that the TPB may be missing a link between intentions and behaviors, suggesting that goal setting (e.g., implementation intentions) may be the key to translating intentions to actions.

Gollwitzer (1993) was the first to introduce the notion of implementation intentions as the means by which intentions can be translated to behavior. He points out that while forming a goal or intention does encourage the realization of a behavior, it does not guarantee that this behavior will be carried out. Gollwitzer proposed that the gap between intentions and behavior can be bridged by forming implementation intentions, which involves specifying when, where, and how the target behavior will be implemented. By linking an intention to specific environmental conditions, "people pass on control of goal-directed activities from the self to the environment" (Gollwitzer, 1993, p. 153) and therefore increase the likelihood of completing the behavior.

Research has shown that the formation of implementation intentions can increase the likelihood that intentions are in fact translated to behavior. Orbell, Hodgkins, and Sheeran (1997) were interested in ways in which the likelihood of women conducting breast self-exams (BSE) can be increased. They proposed that the formation of implementation intentions would lead to women actually performing this behavior. All participants were given a TPB-based questionnaire, with half of the participants receiving the implementation intention intervention. Participants in the intervention condition were asked to specify when and where they would perform BSE in the next month. After one month, participants completed a follow-up questionnaire to determine if they had performed BSE. At the follow-up, over 60% of women in the intervention condition had performed BSE compared to less than 15% of the control group, a difference that was significant. Further, women in the intervention condition reported performing BSE under the conditions they specified in their implementation intentions and were less likely to report forgetting to perform BSE.

In a related study, Browne and Chan (2012) sought to apply implementation intentions to another important aspect of health: mammograms. Specifically, implementation intentions were used to encourage daughter-initiated conversations regarding mammograms with their mothers. The authors hypothesized that women who formed implementation intentions would be more likely to initiate these conversations and that women who expressed higher levels of intention to carry out the conversation would be more susceptible to the implementation intention manipulation. Both the control and experimental groups were given a TPB questionnaire followed by a brief paragraph about the importance of talking to family members about mammograms. The experimental group was then asked to form an implementation intention specifying when, where, and how they might have a conversation with an older female family member about mammograms. Approximately eight weeks after completing this questionnaire, participants completed a second questionnaire asking if they had initiated a conversation about mammography with a female family member. Browne and Chan found a "marginally significant [p = .05]" effect of condition on communication; participants who formed implementation intentions were more likely to initiate a conversation about mammography with an older female family member than participants who did not form implementation intentions.

In a study designed to change flossing habits, Lavin and Groarke (2005) asked half of their participants to form implementation intentions regarding when and where they would floss their teeth each day for three weeks. All participants were given a diary in which they recorded whether they used dental floss each day. The TPB variables were also measured prior to the implementation intervention and again three weeks later. An analysis of the data gathered from the diaries indicated that the participants in the implementation intention condition (M = 14.36 days) did not floss significantly more often than participants in the control condition (M = 12.92 days). The authors suggested that one reason for the lack of a significant difference between the conditions may have been due to the short amount of time allotted to collecting flossing data. Previous research (Sheeran & Orbell, 1999; cited by Lavin & Groarke) reported that implementation intentions do not show effects on behavior until after three weeks have passed.

In a study examining ways to effect changes in diet, Armitage (2006) provided support for the notion that implementation intentions may be more effective when behavior is measured at least a month after forming these intentions. In this study, over 500 participants were asked to complete a questionnaire that measured dietary intake, TPB components, and stage of change, which was measured at baseline and follow-up (one month later). Stage of change was measured using a five-point categorical scale that assessed the degree to which participants had begun to adopt a healthy diet. Half of the participants were assigned to an experimental condition in which they were asked to form an implementation intention regarding their diet. Specifically, participants described how and when they would implement a plan to eat a low-fat diet for a month. The remaining participants were assigned to the control condition and did not form implementation intentions. Armitage found that significantly more participants progressed from their baseline stage of change in the experimental condition relative to the control condition. However, forming implementation intentions did not prevent regression from initial stage of change, as regression rates were similar for the two groups. Armitage suggests that to prevent regression, implementation intentions may need to be more directed rather than self-generated. However, he concludes that these findings do indicate that the formation of implementation intentions can motivate people to engage in a target behavior.

In another study demonstrating the utility of implementation intentions in changing diet, Karimi-Shahanjarini, Rashidian, Omidvar, and Majdzadeh (2013) compared the effectiveness of two interventions designed to reduce unhealthy snacking behavior in young Iranian women. One intervention was based on the theory of planned behavior (TPB only) and the other combined the TPB intervention with implementation intentions. Both groups received booklets that included a persuasive message designed to change attitudes, subjective norms, and perceived behavioral control. Additionally, the implementation intention group received information about the benefits of forming implementation intentions and was asked to write down specific goals for reducing unhealthy snacking. A control group was also included in the study who did not receive the intervention. Measurements of snacking behavior (food frequency questionnaire) were taken at baseline, 10 days after receiving the intervention, and three months after that. The results of this study revealed that participants in both intervention groups reported decreased snacking intentions relative to the control group post-intervention, with the implementation intentions group reporting the lowest intention as expected. At the three-month follow-up, only the implementation intentions group showed significant effects of the intervention on intentions and actual behavior.

It is evident that the TPB can be successfully applied to the prediction of intentions to engage in certain behaviors. Additionally, interventions based on the TPB have been shown to cause changes in both intentions and behavior. However, a weakness of the theory that has been identified in previous research is the loose connection between intentions and actual behavior. Research has demonstrated that implementation intentions can serve as a mechanism for translating intentions into actions. Taken together, the TPB and implementation intentions research literatures provide an opportunity to both educate drivers about high beam usage and to improve high beam usage under the appropriate conditions. There is reason to believe that high beams are underused by drivers, indicating that there is a need for research in this area.

The purpose of the present project was to design and evaluate the effectiveness of an educational intervention based primarily on the TPB. The goal of the intervention was to encourage the appropriate use of high beam headlamps by providing young drivers with new information that has been tailored to address salient attitudes and beliefs about the usage of high beam headlamps. Additionally, this intervention was designed to improve drivers' understanding of the visual challenges associated with driving at night.

The first study was designed, in part, to identify salient beliefs and attitudes about nighttime driving and high beam use. The findings presented by Greaves et al. (2013) suggest that it is important to gather information about beliefs and behaviors from the target population prior to designing a TPB-based intervention in order to ensure that it is relevant to the target population. In a manner similar to that used by Greaves et al. (2013), the first component of the first study involved small focus groups made up of undergraduate students who provided information about beliefs and behaviors in regards to high beam usage. This information was then translated into a TPB questionnaire used in the second component of the first study. Ajzen (2011) recommends "obtain[ing] information about the relative contributions of attitudes, subjective norms, and perceptions of behavioral control to the prediction of intentions…all of this information can help guide the development of an intervention strategy" (p. 86). Participants recruited for the second component of the first study completed a TPB questionnaire that focused on high beam usage. Data gathered in this portion of the first study informed the design of the intervention delivered in the second study; specifically, the intervention focused on providing information that addressed the strongest predictor of intention to use high beams (i.e., attitude toward high beam usage) as identified by the first study.

The second study was used to deliver and evaluate a TPB-based intervention. In this study, both self-report and objective on-road data were gathered to assess the effectiveness of the TPB-based intervention in improving drivers' use of high beam headlamps. Additionally, approximately half of the participants who received the intervention formed implementation intentions specifying the conditions under which they would use high beams for the following month. Participants documented their high beam usage on a daily basis for three to four weeks. Data from participants who formed implementation intentions were compared to data from those who did not; it was hypothesized that participants who were asked to form implementation intentions would report using high beams more often than intervention participants who did not form implementation intentions. Additionally, on-road measures of high beam usage were recorded while participants drove their own vehicles along a pre-determined route designed to offer ample opportunity to use high beams. It was expected that the intervention group would use their high beams more often than the participants in the control group.

STUDY 1

Method

Participants

One hundred-seventeen Clemson University undergraduate students 18-25 years of age participated in this study. Participants received course credit in exchange for participation. All participants possessed a valid driver's license.

Design

This study was divided into two components: focus groups designed to gather qualitative data in reference to young drivers' beliefs about night driving and high beam headlamp usage, and the design of a questionnaire to assess the relationship between the TPB predictors (attitude, subjective norm, and perceived behavioral control) and intentions to use high beams. Sixteen participants (13 males, 3 females) were recruited to take part in one of four focus groups that took place over the course of three days. Three to five participants took part in each focus group. The remaining 101 participants (25 males, 76 females) were asked to provide quantitative data that was used to predict intentions to use high beams.

Focus groups

A semi-structured group interview was conducted to identify participants' salient beliefs about driving at night and the factors influencing their use of high beams in the absence of oncoming or leading traffic. In order to develop an understanding of these salient beliefs in the framework of the TPB, participants were asked about the advantages and disadvantages of using high beams (attitude), the factors that may facilitate or inhibit the use of high beams (perceived behavioral control), and if there are any people in their lives who would or would not want them to use high beams (subjective norm) (Ajzen, 2011). Additionally, participants were encouraged to discuss their understanding of visual functions at night and asked what they believe are the differences between low and high beam headlamps in terms of the pattern of light projected onto their forward view of the roadway. An experimenter transcribed participants' responses to these prompts. Each focus group lasted 20-30 minutes.

Questionnaire

The questionnaire (see Appendix A) used in Study 1 contained 18 questions. Participants first provided demographic information (i.e., age, gender, and years of driving experience) and then estimated the percentage of time their high beams were used in the past month in the absence of oncoming and leading traffic based on the amount of time spent driving at night. The remainder of the questionnaire was designed to assess the relationship between attitude, subjective norm, perceived behavioral control, and intentions. The questionnaire contained 13 items specifically related to the TPB. Attitude was measured using five items, two of which were rated on 7-point Likert scales ranging from 1 = strongly disagree to 7 = strongly agree; the other three items addressing attitude were rated on 7-point bipolar adjective scales (e.g., unnecessary – necessary). Four items were used to measure subjective norm; participants responded to two of these statements using the previously discussed 7-point Likert scale while the remaining two items were rated on a 7-point scale ranging from 1 = strongly disapprove to 7 = strongly approve. Perceived behavioral control was measured using two items, both of which required participants to rate their level of agreement with the statements on a 7-point scale. Finally, intention to use high beams was assessed through two items, with participants first rating their level of agreement with the statement that they would use their high beams in the absence of traffic with clear weather conditions in the next month. The second statement asked participants to rate the likelihood of using their high beams under these same conditions.

Data from 57 participants were used to assess the reliability of the items designed to measure each TPB component. The results of these assessments indicated that the measures of attitude (Cronbach's $\alpha = .87$), subjective norm (Cronbach's $\alpha = .83$), and intention (Cronbach's $\alpha = .96$) were all reliable (Nunnally & Bernstein, 1994). The items used to measure perceived behavioral control were less reliable (Cronbach's $\alpha = .59$); however, there was a significant Pearson's correlation ($r = .42$, $p = .001$) between these items. Additionally, there is reason to believe that alpha levels below 0.7 may be expected when constructs are measured using fewer (i.e., two or three) items (Rust & Golombok, 1999 as cited by Greaves et al., 2013). Therefore, no items were deleted from the questionnaire.

Results

Focus group data

The qualitative data gathered from the focus groups were assessed using a method similar to that reported by Greaves et al. (2013). Participants' responses (N = 197 comments) were printed on individual pieces of paper and a card sort technique was used to identify the most salient attitudes and beliefs about high beam usage. Two experimenters completed a card sort of responses independently. Any discrepancies in categorization of responses were discussed by the two experimenters until a single categorization was agreed upon. The two experimenters then identified common themes among the categories of responses. For a full list of the themes that were identified for each focus group question, see Appendix B. These data informed the development of the questionnaire used in this study as well as the intervention that was delivered to new participants in Study 2. Specifically, the statements used in the questionnaire were tailored to the population (i.e., young drivers) based on the information gathered from the focus group. For example, one of the themes identified by the attitude prompts indicated that the young drivers felt that the use of high beams allowed them to see the roadway better than they might when using low beams. Therefore, the questionnaire contained an item that asked participants to rate their level of agreement with a statement that corresponded to this attitude.

Questionnaire data

Prior to analyzing the questionnaire data, the sets of items that constituted the measures of each TPB component were averaged to create a mean score for each component, including intention to use high beams. The data were first screened for outliers; two outliers ($z > 3$) were identified. However, removal of these outliers did not significantly alter the regression model. Therefore, data from 57 participants were analyzed in order to determine the best predictor of intentions to use high beam headlamps to guide the development of the intervention for Study 2. Hierarchical regression was conducted to examine the ability of the TPB and other variables to predict participants' intentions to use high beams. Intention was entered as the dependent variable in the analysis. Demographic information (i.e., gender, age, driving experience) was entered in the first step of the regression, the TPB components (attitude, perceived behavior control, and subjective norm) in the second step, and estimated high beam usage in the third and final step as an indicator of past behavior. The combination of gender, age, and driving experience accounted for 3% ($p > .05$) of the variance in intention to use high beams (see Table 1). The addition of the TPB components accounted for an additional 59% of the variance in intention ($p < .001$). The subsequent addition of estimated high beam usage to the model accounted for an additional 7% of the variance ($p = .002$). In sum, 69% of the variance in intention to use high beams was accounted for by the full model. At the final step of the analysis, the significant predictors of intentions to use high beams were estimated high beam usage ($p < .05$) and attitude ($p < .001$).

Table 1. Reported statistics for hierarchical regression predicting intention to use high beams.

	B	**SE**	**β**	**Δ R^2**
Step 1				
Age	-.02	.04	-.04	.03
Gender	.41	.37	.10	
Driving experience	.07	.09	.06	
Step 2				
Attitude	.76**	.19**	.49**	.59**
Perceived behavioral control	.07	.12	.05	
Subjective norm	.21	.16	.14	
Step 3				
Estimated high beam usage	.02*	.004*	.34*	.07*

Note: Weights provided are those found in the final step of the analysis
* $p < .05$
** $p < .001$

Because there was a correlation between two predictors (i.e., attitude and subjective norm; see Table 2), it is possible that the regression coefficients were potentially an inaccurate index of the variables' relative importance. Therefore, relative importance analysis (Tonidandel & LeBreton, 2011) was used to calculate the relative weight of each predictor. The results of the analysis confirmed that high beam usage and attitude were the predictors that accounted for the most variance in intentions (see Table 3).

Table 2. Means, standard deviations, and correlations between intention to use high beams and predictors.

	I	A	G	DE	Att	SN	PBC	EHB	*M*	*SD*
Intention (I)	-	.15	.05	.13	.77**	.57**	.07	.66**	5.33	1.74
Age (A)		-	.36*	.11	.16	-.03	-.02	.21	16.61	4.04
Gender (G)			-	-.04	.04	-.13	.02	-.10	1.79	.41
Driving experience (DE)				-	.11	.16	-.21	.04	3.78	1.59
Attitude (Att)					-	.65**	-.05	.55**	5.88	1.13
Subjective norm (SN)						-	-.03	.35**	4.78	1.17
Perceived behavioral control (PBC)							-	.18	6.08	1.18
Estimated high beam usage (EHB)								-	42.02	39.85

* $p < .05$
** $p < .001$

Table 3. Relative importance analysis predicting intention to use high beams.

Predictor	Relative weight	Rescaled relative weight
Age	.007	1.00
Gender	.007	1.03
Driving experience	.008	1.13
High beam usage	.22	32.10
Attitude	.30	43.44
Perceived behavioral control	.14	20.40
Subjective norm	.006	.90

Note: Relative weights are relative effect sizes and sum to the model R^2; rescaled relative weights are a percentage of predictable variance and sum to 100.

In order to confirm the findings of the first regression analysis, questionnaire data were collected from an additional 44 participants, for a total sample size of 101 participants. Prior to conducting the regression, the data were again screened for outliers. Four outliers ($z > 3$) were identified; removal of these outliers resulted in previously non-significant predictors becoming significant so these outliers were removed. Therefore, data from 97 participants were analyzed to confirm the findings of the initial regression and importance analyses. The same hierarchical regression procedure was used to determine which variables significantly predicted intention to use high beams. The combination of gender, age, and driving experience accounted for 4% ($p > .05$) of the variance in intention to use high beams (see Table 4). The addition of the TPB components accounted for an additional 34% of the variance in intention ($p < .001$). Finally, the addition of estimated high beam usage to the model accounted for an additional 4% of the variance ($p < .05$). In sum, 41% of the variance in intention to use high beams was accounted for by the full model. At the final step of the analysis, the significant predictors of intentions to use high beams were estimated high beam usage (*p*

< .05), attitude ($p < .05$), perceived behavioral control ($p < .05$), and subjective norm ($p =$ .05).

Table 4. Reported statistics for the second hierarchical regression predicting intention to use high beams.

	B	**SE**	**β**	**Δ R^2**
Step 1				
Age	.02	.04	.06	.04
Gender	-.18	.26	-.06	
Driving experience	.01	.07	.02	
Step 2				
Attitude	.51*	.19*	.28*	.34**
Perceived behavioral control	.22*	.10*	.19*	
Subjective norm	.26*	.13*	.19*	
Step 3				
Estimated high beam usage	.01*	.003*	.23*	.04*

Note: Weights provided are those found in the final step of the analysis
* $p < .05$
** $p < .001$

Analysis of the data from all 97 participants indicated that there were significant correlations between all three of the TPB components (see Table 5); therefore, relative importance analysis was again used to calculate the relative contribution of each of the predictors to variance in intention to use high beams. The results of the second relative importance analysis (see Table 6) indicated that attitude was the predictor with the highest relative weight followed by high beam usage, thus confirming the findings of the previous analyses.

Table 5. Means, standard deviations, and correlations between intention to use high beams and predictors.

	I	A	G	DE	Att	SN	PBC	EHB	*M*	*SD*
Intention (I)	-	.15	-.07	.04	.53**	.42**	.33**	.47**	5.86	1.29
Age (A)		-	.24*	.19*	.22*	-.04	.01	.23*	18.81	3.20
Gender (G)			-	-.07	.03	-.08	.02	-.10	1.75	.43
Driving experience (DE)				-	.007	.03	-.03	.01	3.80	1.53
Attitude (Att)					-	.51**	.17*	.47**	6.24	.72
Subjective norm (SN)						-	.18*	.20*	5.07	.94
Perceived behavioral control (PBC)							-	.26*	6.12	1.20
Estimated high beam usage (EHB)								-	49.02	37.97

* $p < .05$
** $p < .001$

Table 6. Second relative importance analysis predicting intention to use high beams.

Predictor	Relative weight	Rescaled relative weight
Age	.01	2.94
Gender	.004	1.20
Driving experience	.001	.17
High beam usage	.11	26.36
Attitude	.14	33.46
Perceived behavioral control	.06	14.76
Subjective norm	.09	21.11

Note: Relative weights are relative effect sizes and sum to the model R^2; rescaled relative weights are a percentage of predictable variance and sum to 100.

Discussion

The purpose of Study 1 was to develop a questionnaire based on the theory of planned behavior allowing for the investigation of antecedents to intentions to use high beam headlamps. In order to do this, the target population (i.e., younger adult drivers) was engaged in the development of the questionnaire items in order to ensure the relevance of the items to this population. This questionnaire was then used to develop the educational intervention to be delivered as a part of Study 2.

In order to develop the TPB-based questionnaire, 16 younger drivers were interviewed in a structured, group interview setting about their attitudes toward and usage of high beams. Major themes in response to each question were then identified using a card sort technique. Based on this card sort, several themes (i.e., three to six) emerged for each question. These themes identified in the focus groups were translated into statements suitable for use with 7-point rating scales. To be maximally relevant to the target audience, the statements were framed in the context of a typical high beam usage scenario (i.e., unlit road with low traffic density and clear weather) as reported by participants in the focus groups. This translation of focus group data to questionnaire items yielded 18 items, 13 of which assessed the three antecedents of intention to use high beams and also measured actual intentions. Each component was assessed using at least two items.

Preliminary analysis of the questionnaire data (N = 57) indicated that the TPB constructs accounted for 59% of the variance in intentions to use high beams. Estimated previous high beam usage and attitude toward high beam usage were both significant predictors of intentions in this model, a finding confirmed by a relative importance analysis. The primary goal of gathering questionnaire data was to determine the TPB component that best predicted intentions to use high beams in order to target this component in the educational intervention in Study 2. Based on the results of the preliminary analyses of the questionnaire data, a portion of the educational intervention focused on attitudes toward high beam usage. Data from the focus groups indicated that attitudes toward high beam usage included the fact that high beams improve visual abilities and allow drivers to see more of the roadway.

In order to confirm the findings of the preliminary analyses suggesting that attitude was the predictor of intention to use high beams with the greatest relative weight, data from an additional 44 participants were gathered and analyzed. This analysis yielded slightly different findings in that perceived behavioral control and subjective norm also emerged as significant predictors of intention to use high beams. However, a second relative importance analysis indicated that attitude was the “most important” predictor, confirming the findings of the preliminary analyses of questionnaire data.

The purpose of Study 1 was to develop a TPB questionnaire and to gather data using this questionnaire to determine the best predictor of intentions to use high beam headlamps. As a result of this study, it was determined that young drivers' attitudes toward high beams were the predictor that best explained variance in intentions. Therefore, an intervention that both educated drivers about the problems associated with driving at night as well as targeted common attitudes toward high beam usage was developed for use in Study 2.

STUDY 2

Method

Participants

Forty-six Clemson University undergraduate students 18-25 years of age (M = 19.9, SD = 2.0) participated in this study. Participants received course credit in exchange for participation and were given the opportunity to earn additional cash incentives. All participants possessed a valid driver's license and had access to a registered, insured vehicle. Additionally, all participants achieved a minimum binocular acuity of 6/12 (20/40) and reported having no known visual pathology (other than corrected refractive error).

Design

Twelve of the participants were recruited from an Introductory Psychology course that received a lecture about visual perception and challenges faced by drivers at night. This 50-minute lecture included information regarding the benefits of high beam usage relative to low beam usage, among other related topics (e.g., selective degradation, pedestrian visibility at night, retroreflection). The information contained in the lecture was based in part on the findings of Study 1. Specifically, attitudes towards high beam usage were identified as a key predictor of intentions to use high beams appropriately as the first study and were therefore targeted during the intervention. In order to address this component, the experimenter who delivered the lecture discussed the visibility benefits provided by illumination from high beams, sharing empirical data to support this point. The experimenter also encouraged the audience to use their high beams whenever possible to maximize visual abilities at night. The remaining 34 participants (control group) were recruited from Psychology courses that did not receive the lecture about night driving.

During the first experimental session, participants were asked to complete the TPB questionnaire developed in Study 1; the end of the questionnaire included the following instructions for the implementation intention condition: “In the absence of oncoming and leading traffic at night, we want you to plan to use your high beam headlights as often as possible when driving at night. You may choose how and when to do this, but we ask that you outline your specific plans to do this over the next month. Please pay particular attention to the situations (e.g., type of roadway; traffic volume; time of night) in which you plan to implement high beam usage.” Seven (58%) of the participants in the intervention group were randomly assigned to this condition. Two dependent variables, self-reports of beam usage and actual beam usage during the second experimental session, were used to assess the effectiveness of forming implementation intentions.

Procedure

At least three weeks after the lecture about night driving was delivered, participants from the course that received the lecture as well as from courses that did not were recruited to participate in a two-part study; none of these students participated in Study 1. During the first experimental session, participants completed the TPB questionnaire developed in Study 1, providing a unique identifier (i.e., their Clemson University username) that allowed their responses to be matched with data collected in subsequent experimental sessions. Additionally, during the first session, participants were informed that they would receive an email on a daily basis containing a link to a questionnaire (see Appendix C) to record various driving behaviors (e.g., use of navigational aid(s), listening to the radio), including when and under what conditions (e.g., type of road driven, estimated traffic volume) they used their high beams. Participants were asked to complete the daily questionnaire for the time that elapsed between the first and second experimental sessions (i.e., at least three weeks). For each week in which the daily survey was completed at least five times, participants earned $5.

After at least three weeks elapsed, participants returned for the second experimental session during which time on-road high beam usage was recorded. Data were collected at least one hour after sunset and only on nights free of precipitation and fog. Participants drove their own vehicles to campus, where they were joined by two experimenters. They were told they would take a short drive around campus during which time a video camera would record what happened as they drove; they were not alerted to the fact that high beam usage was being recorded.

Two experimenters were always present in the participant's vehicle during data collection, with one riding in the front passenger seat and one in the rear seat. The experimenter in the front seat documented the participant's high beam usage throughout the drive, recording whether any leading or opposing vehicles were present on the road whenever high beams were activated. To measure high beam usage, the rear seat experimenter held and aimed a small video camera that recorded the dashboard and the forward view of the roadway as the participant drove a pre-specified experimental route. The camera was connected to a laptop that recorded the video. Data from this video feed was later coded and compared to the other experimenter's documentation of beam usage to ensure accurate calculation of the percentage of time high beams were used appropriately. In order to code the video data, an experimenter coded each video twice. During the first viewing, the experimenter recorded the total amount of time during the drive that high beam usage would be recommended due to the absence of leading and oncoming vehicles. The amount of time high beams were used was documented during the second viewing of each video; instances of high beam use were determined by monitoring both the dashboard indicator and the beam pattern on the roadway.

Prior to the drive, the rear seat experimenter briefly explained the procedure and answered any questions. Participants were told that they would take a short drive (following the route guidance provided by the rear seat experimenter) and that they should drive at a comfortable speed. They were told that a camera would be recording what happened as they drove. They then drove a predetermined route that included a stretch designed to minimize both ambient illumination and traffic, therefore providing participants with several opportunities to use their high beam headlamps. This portion of the route (see Figure 2) was 2.6 km (1.6 miles) long and took participants approximately five minutes to complete (mean speed approximately 30 mph).

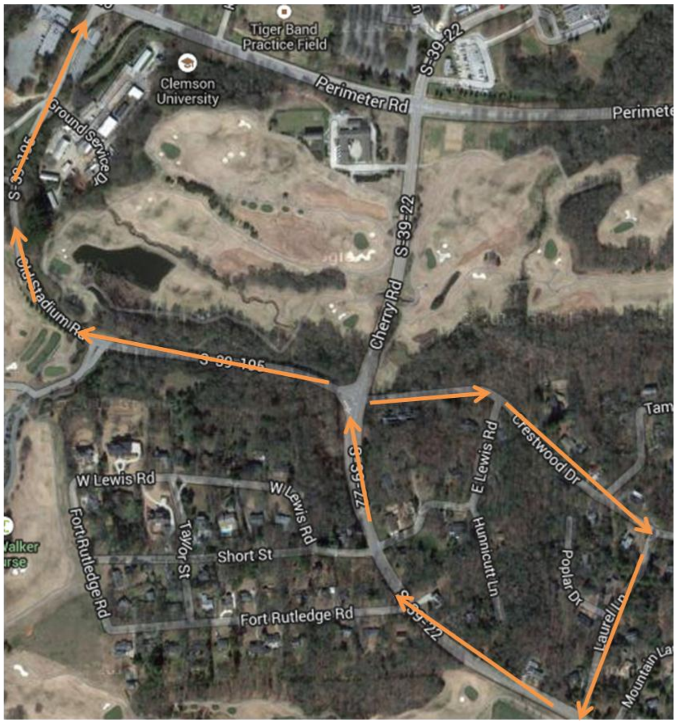

Figure 2. The route driven by participants that was used to record high beam usage.

Participants then returned to the original meeting spot, where they picked up one or two experimenters who directed them to drive to an unilluminated area of a parking lot on campus where beam measurements were taken. Illuminance levels (in lux) of the low and high beam headlights for each participant’s vehicle were measured. Measurements were taken 30.5 m (100 ft) from the front of the midline of the vehicle at 15.2 cm above ground level. At the conclusion of the session, participants were asked to read and initial a debriefing form that disclosed the purpose of the in-vehicle camera. Participants then returned the experimenter to the original meeting spot and were thanked for their participation.

Results

TPB questionnaire

Prior to analyzing the questionnaire data the sets of items that constituted the measures of each TPB component were averaged to create a mean score for each component, including intention to use high beams. The data were then screened for outliers. One participant was identified as an outlier ($z > 3$) based on their average intention score. Rather than remove this participant's data from all subsequent analyses, this outlying data point was replaced by the mean intention rating (5.4) for that participant's experimental group (i.e., control) for this and the subsequent regression analysis. For this hierarchical regression, age, gender, and driving experience were entered in the first step, the three TPB components were entered in the second step, estimated high beam usage was entered in the third step, and experimental group was dummy coded (intervention = 1, control = 0) and entered in the fourth and final step in order to determine if the intervention group was significantly different from the control group in their intentions to use high beam headlamps.

The combination of gender, age, and driving experience accounted for 24% of the variance in intention to use high beams, $p < .05$ (see Table 7). The addition of the TPB components accounted for an additional significant 41% of the variance in intentions, $p < .001$. The subsequent addition of estimated high beam usage to the model accounted for an additional significant 7% of the variance, $p < .05$. Finally, adding experimental group to the model did not result in a significant change in variance accounted for by the model,

$p > .05$. This indicates that membership in the intervention vs. control group did not significantly affect intention to use high beams, as predicted. In sum, 72% of the variance in intention to use high beams was accounted for by the full model. At the final step of the analysis, the significant predictors ($p < .05$) of intentions to use high beams were estimated high beam usage, attitude, and perceived behavioral control. See Table 8 for descriptive statistics and correlations between intention and predictors.

Table 7. Reported statistics for hierarchical regression predicting Study 2 participants' intention to use high beams.

	B	**SE**	**β**	**Δ R^2**
Step 1				
Age	-.04	.12	-.06	.24*
Gender	-.03	.29	-.01	
Driving experience	.09	.12	.12	
Step 2				
Attitude	.44*	.16*	.38*	.41**
Perceived behavioral control	.51*	.18*	.29*	
Subjective norm	.19	.17	.14	
Step 3				
Estimated high beam usage	.01*	.004*	.31*	.07*
Step 4				
Experimental group	.15	.31	.05	.002

Note: Weights provided are those found in the final step of the analysis
* $p < .05$
** $p < .001$

Table 8. Means, standard deviations, and correlations between Study 2 participants' intention to use high beams and predictors.

	I	A	G	DE	Att	PBC	SN	EHB	EG	*M*	*SD*
Intention (I)	-	-.29*	-.32*	-.04	.70**	.51**	.61**	.63**	.21	5.69	1.36
Age (A)		-	.05	.76**	-.41*	-.17	-.31*	-.22	-.01	19.93	.195
Gender (G)			-	-.01	-.24	-.32*	-.20	-.30*	-.18	1.72	.46
Driving experience (DE)				-	-.14	.06	-.17	-.12	-.19	4.59	1.84
Attitude (Att)					-	.25*	.70**	.43**	.12	5.92	1.16
Perceived behavioral control (PBC)						-	.17	.27*	.12	6.47	.76
Subjective norm (SN)							-	.46**	.23*	5.06	1.02
Estimated high beam usage (EHB)								-	.21	40.43	38.24
Experimental group (EG)									-	.26	.44

* $p < .05$
** $p < .001$

Self-reports of high beam use

Self-reports of the frequency of high beam usage in the absence of oncoming and leading traffic were compared between the implementation intention group and the intervention participants that did not form implementation intentions. An independent samples *t*-test was used to compare self-reports between the two groups. The results of this analysis indicated that there was not a significant difference in self-reports of high beam usage between participants who formed implementation intentions (M = 3.57, SD = 2.70) and the intervention participants who did not (M = 3.40, SD = 2.51), $t(10) = -.11$, $p > .05$, Cohen's $d = .07$.

On-road measures of high beam usage

Hierarchical regression was used to assess the utility of the TPB in predicting on-road high beam usage. Similar to the regression predicting intentions, demographic information (i.e., age, gender, driving experience) were entered in the first step, followed by the TPB components. Unlike the previously discussed regression, intention was entered as a predictor in the third step, estimated high beam usage in the fourth step, and experimental group (dummy coded) was still entered as the last step. The dependent variable was the amount of time (in minutes and seconds) that high beams were used during testing divided by the total amount of time (in minutes and seconds) that high beam use was clearly advised (i.e., whenever no oncoming or leading vehicles were present), yielding the percentage of time high beams were used appropriately. The results of the regression analysis (see Table 9) indicated that demographic information did not account for a significant proportion of the variance in high beam usage, $p > .05$. The subsequent addition of the three TPB components as well as intentions resulted in an additional combined 38% increase ($p < .05$) in the model's prediction of high beam usage. Including estimated high beam usage resulted in a 7% increase in variance accounted for by the model, $p < .05$. Finally, experimental group did not significantly ($p > .05$) increase proportion of variance accounted for by the model. The full model accounted for 52% of the variance in high beam usage. In the final step of the regression model, the significant predictors of high beam usage were estimated high beam usage ($p < .05$), subjective norm ($p = .005$), and intentions ($p < .05$). Attitude toward high beam usage was a marginally significant predictor ($p = .07$) of high beam usage. As predicted, perceived behavioral control did not emerge as a significant predictor of on-road high beam usage. See Table 10 for descriptive statistics and correlations between beam usage and predictors.

Table 9. Reported statistics for hierarchical regression predicting on-road high beam usage.

	B	**SE**	**β**	**Δ R^2**
Step 1				
Age	.04	.04	.21	.07
Gender	-.03	.09	-.04	
Driving experience	-.007	.04	-.04	
Step 2				
Attitude	.11	.06	.37	.19*
Perceived behavioral control	-.05	.06	-.12	
Subjective norm	-.17	.06	-.52	
Step 3				
Intention	.13	.05	.51	.19**
Step 4				
Estimated high beam usage	.003	.001	.35	.07*
Step 5				
Experimental group	-.05	.10	-.07	.004

Note: Weights provided are those found in the final step of the analysis
* $p < .05$
** $p < .001$

Table 10. Means, standard deviations, and correlations between on-road high beam usage and predictors.

	HB	A	G	DE	Att	PBC	SN	I	EHB	EG	*M*	*SD*
High beam usage (HB)	-	-.01	-.23	.10	.40*	.21	.12	.55**	.52**	.02	48.15	33.79
Age (A)		-	.05	.76**	-.41*	-.17	-.31*	-.29*	-.22	-.10	19.93	1.95
Gender (G)			-	-.01	-.24	-.32*	-.20	-.32*	-.30*	-.18	1.72	.46
Driving experience (DE)				-	-.14	.06	-.17	-.04	-.12	-.19	4.59	1.84
Attitude (Att)					-	.25*	.70**	.70**	.43**	.12	5.92	1.16
Perceived behavioral control (PBC)						-	.17	.51**	.27*	.12	6.47	.76

Subjective norm (SN)	-	.61**	.46**	.26*	5.06	1.02
Intention (I)		-	.63**	.21	5.69	1.36
Estimated high beam usage (EHB)			-	.21	40.43	38.24
Experimental group (EG)				-	.26	.44

* $p < .05$
** $p < .001$

A one-way ANOVA with two focused contrasts (Rosenthal & Rosnow, 2008) tested the predictions: (1) that the intervention group, overall, would use their high beams more often than participants in the control group; and (2) that the intervention participants who formed implementation intentions would use their high beams more often than the intervention participants who did not form implementation intentions. The dependent variable was the percentage of time high beams were used appropriately. One participant used their high beams more than was appropriate (i.e., more than 100% of the time) and was identified as a potential outlier. However, removal of the participant's data did not alter the results of the following analyses; therefore, this participant's data was included. The results of the omnibus *F* test indicated that there was not a significant effect of experimental group on high beam usage, $F(2, 43) = .05$, $p > .05$, $\eta^2 = .002$ (see Figure 3). The first contrast comparing the control group ($M = 48\%$, $SD = 34\%$) to the overall intervention group ($M = 49\%$, $SD = 36\%$) did not result in a significant difference between the two groups, $t(43) = .17$, $p > .05$. The second contrast that compared high beam usage between participants who formed implementation intentions ($M = 47\%$, $SD = 29\%$) and participants who only heard the intervention ($M = 53\%$, $SD = 48\%$) indicated that there was not a significant difference between these groups, $t(43) = -.29$, $p > .05$.

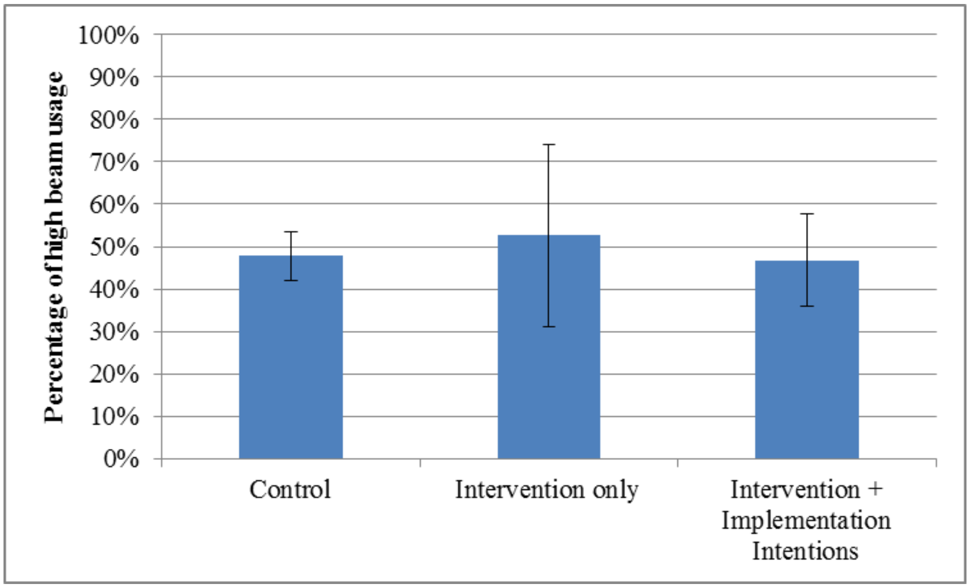

Figure 3. Mean percentage of high beam usage (±1 SEM) as a function of experimental group.

Prior to data analysis, it was hypothesized that an inverse relationship would exist between vehicle low beam illumination and high beam usage; specifically, I hypothesized that participants who drove vehicles with relatively modest low beam output would tend to use their high beams more often. In order to test this hypothesis, a one-tailed Pearson's correlation coefficient was calculated. The results of this analysis indicated that, across the control and intervention groups, the relationship between low beam illumination and high beam usage was a moderately negative one, $r(44) = -.23$, $p = .06$ (see Figure 4), such that drivers whose low beams produced less illumination tended to use their high beams more often. Two separate one-tailed correlation coefficients were calculated to specifically examine this relationship within the control group and within the intervention group overall. The results of the first analysis revealed that for the control group, the correlation between low beam illumination and high beam usage was not significant, *r*(32) = -.15, *p* > .05 (see Figure 5). The analysis assessing this relationship within the intervention group indicated that there was a moderately negative correlation, *r*(10) = -.42, *p* = .09 (see Figure 6). This correlation was stronger than this same relationship when ignoring group membership as well as within the control group. Further, exploratory analysis revealed that there were no significant correlations between high beam illumination and high beam usage (*p* > .05) within either the control or intervention groups. Additionally, there were no significant correlations between the difference in illumination between low and high beams and high beam usage (*p* > .05).

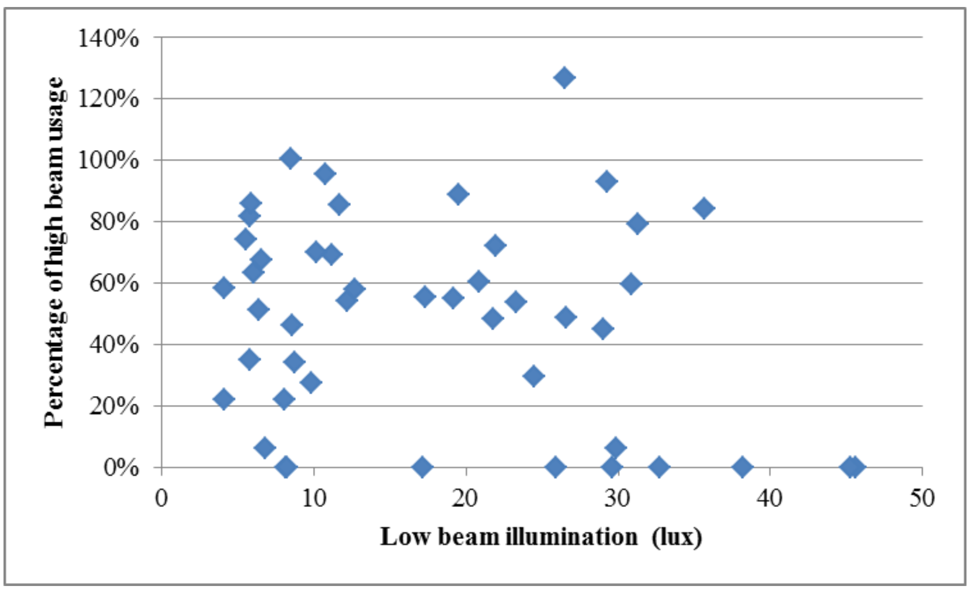

Figure 4. The relationship between low beam illumination (in lux) and on-road high beam usage across both groups.

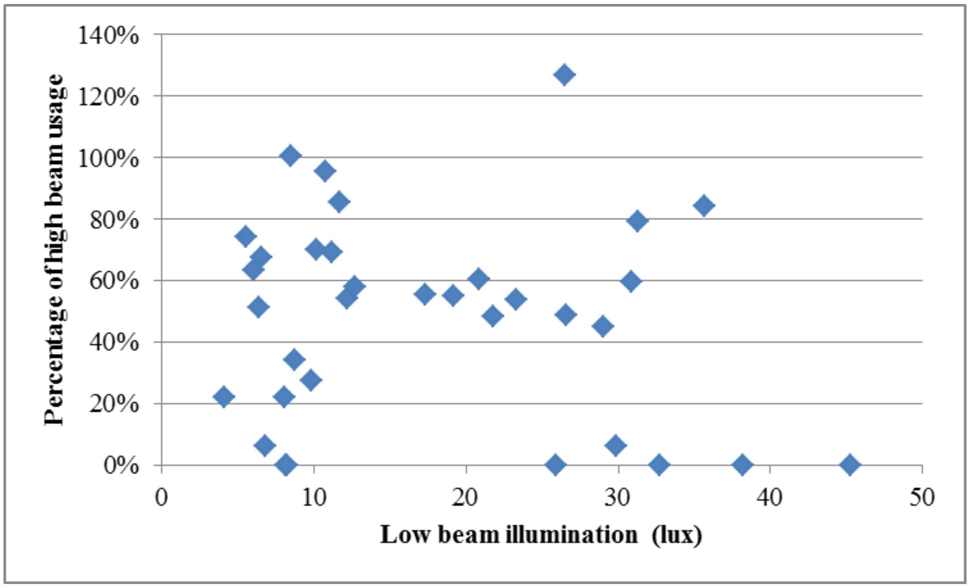

Figure 5. The relationship between low beam illumination (in lux) and on-road high beam usage for participants in the control group.

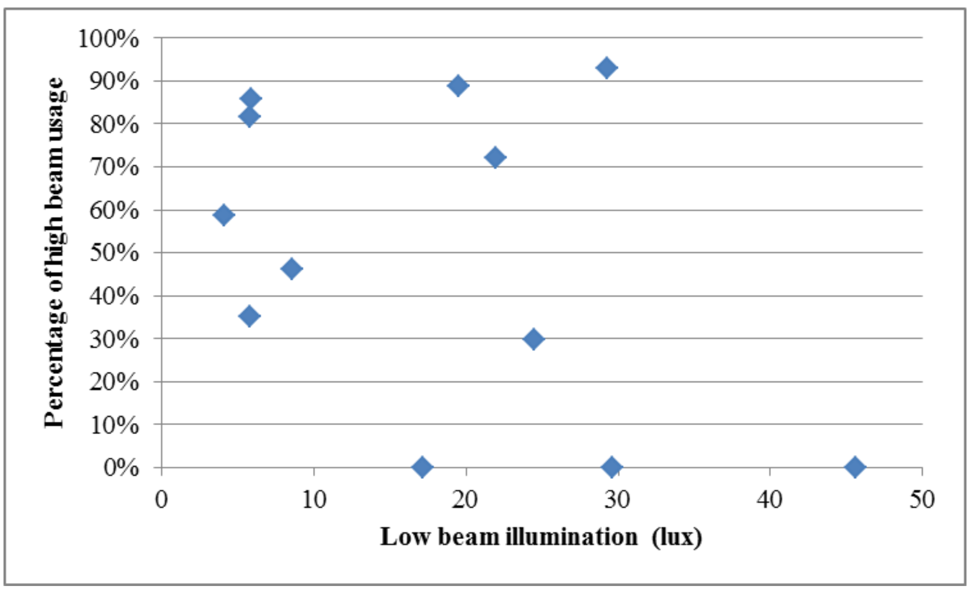

Figure 6. The relationship between low beam illumination (in lux) and on-road high beam usage for participants in the intervention group overall.

Discussion

The purpose of the present work was to design and evaluate an intervention to increase young drivers' appropriate use of high beam headlamps. Based on the results of Study 1, attitudes toward high beam headlamps were the focus of a Theory of Planned Behavior-based intervention that was delivered in Study 2. Participants who were enrolled in one section of an Introductory Psychology course had heard a lecture describing the visual challenges associated with driving at night and the ways in which high beam usage can mitigate these challenges. At the time of the lecture, the students were not aware that it would be related to ongoing research. After hearing this lecture, three to six weeks (22 - 43 days; M = 38 days) elapsed before students were invited to participate in the present study. After the first session in which participants were informed of the requirements of the study and completed a TPB questionnaire (part of which included the formation of implementation intentions for some of the intervention group), an additional 21 to 28 days (M = 23.1 days) passed before participants completed an open-road drive during which time high beam usage was recorded. During the time that passed between the first and second experimental sessions, participants were asked to complete daily questionnaires about driving behaviors that included self-reporting of high beam usage. The data gathered in this study were used to assess the utility of the TPB in predicting high beam headlamp usage, to evaluate the effect of the intervention and the formation of implementation intentions on high beam use, and to compare high beam usage by drivers in this study to that reported in previous literature.

The first goal of the present study was to determine the extent to which the TPB components predicted drivers' high beam usage recorded in the second experimental session. The results of this analysis suggest that the TPB had some degree of success in predicting high beam usage, accounting for a total of 38% of the variance in high beam use. Specifically, both subjective norm and intentions were significant predictors of the percentage of appropriate high beam usage. This finding indicates that, for drivers in this study, perceptions of whether important people in their lives (e.g., parents) would want them to use high beams as well as self-reported intentions to use high beams when no other traffic was present were predictive of how often high beams were used.

This analysis of high beam usage in the present study allowed for a unique application of the TPB. Several previous studies (e.g., Nemme & White, 2010; Poulter & McKenna, 2010; Zhou, Wu, Rau, & Zhang, 2009) applied the TPB to a variety of driving behaviors (e.g., texting while driving, speeding), but thus far no research has addressed the TPB as a framework for understanding a behavior such as high beam usage. A key distinction between previously studied driving behaviors and high beam usage is that drivers often recognize whether or not they should be completing certain behaviors (e.g., speeding) while many drivers may not be aware that they should use their high beams. This may explain why the TPB was less useful in predicting high beam usage than has been reported for other driving behaviors. High beam usage may be better predicted by factors such as typical high beam usage, rather than factors such as attitude toward this behavior.

The application of the TPB to predicting drivers' use of high beams offers some insight into the factors that may influence this behavior. Previous research (e.g., Buonarosa, Sayer, & Flannagan, 2008; Hare & Hemion, 1968; Sullivan, Adachi, Mefford, & Flannagan, 2003) in this area has focused on documenting high beam usage under a variety of circumstances and reported that drivers tend to rely heavily on their low beams, even when the use of high beams would be appropriate. No research prior to the present study has been concerned with the factors that may determine this underuse of high beam headlamps or with encouraging drivers to use their high beams more appropriately.

While two TPB components (i.e., subjective norm and intentions) were significant predictors of high beam usage, with all of the TPB components combined accounted for a 38% of the variance in drivers' percentage of appropriate high beam use, drivers' estimates of previous high beam use also accounted for a small, significant proportion of variance. Ajzen (1985) argued that past performance of a behavior should not have an effect on present behavior, which is inconsistent with the findings of this study. However, Ajzen goes on to explain that this is only the case when an individual has complete control over the behavior in question. Since the use of high beams is dependent on several factors (e.g., weather conditions, traffic volume) it may be considered a type of behavior over which drivers lack complete control. Additionally, it is possible that drivers' use (both the frequency of and conditions under which) of high beams is a habit developed over time, making previous behavior an important predictor of present behavior. If this is the case, it is therefore logical that estimates of previous high beam usage were revealed to be a significant predictor of this behavior measured in the present study. The fact that at least some of the TPB components predicted drivers' use of high beams suggests that the TPB may be useful as future researchers explore the factors that establish beam usage habits and that predict reliance on high beams. Future research should also continue to investigate how high beam usage habits are established and maintained.

A second goal of the present project was to improve young drivers' use of high beams using two methods: an educational intervention and the formation of implementation intentions. It was hypothesized that exposure to the educational intervention combined with drivers forming implementation intentions would result in the most high beam usage (based on self-reports as well as objective on-road data) relative to the intervention only and control groups. An analysis of self-reports of high beam usage indicated that the intervention group participants who formed implementation intentions did not report using their high beams significantly more often than those intervention participants who did not form implementation intentions. This finding suggests that asking participants to form implementation intentions did not improve their high beam usage as reported by the participants. However, this conclusion should be interpreted with caution given that self-reports of behavior can be inaccurate and prone to socially desirable responding by participants (Lajunen & Özkan, 2011).

In addition to gathering self-reported data, high beam usage during a short open-road drive was also recorded. An analysis of these data revealed no significant differences in mean percentage of appropriate high beam use among the three groups in this study (i.e., control, intervention only, intervention and implementation intentions). While there was a slight tendency for the drivers in the intervention only group to use their high beams more often than other drivers, this difference was non-significant, suggesting that neither exposure to the intervention nor asking participants to form implementation intentions yielded improvements in high beam usage.

The findings of the present study regarding high beam usage are surprising given the selective degradation theory and the proposed effect of knowledge on high beam usage. Specifically, the selective degradation theory suggests that drivers are unaware that their focal (i.e., recognition) vision is degraded at night and therefore do not change behaviors, such as high beam usage, to compensate for this degradation in vision. It was hypothesized that enhancing knowledge about the selective degradation of recognition vision would result in an increase in high beam usage, which was not the case. It is possible that knowledge of visibility problems at night is not sufficient to increase high beam usage, or that for some reason the knowledge is overpowered by the incorrect perception that low beams provide adequate illumination. Therefore, informing drivers about decrements in visual performance at night may not have led to increased high beam usage. Drivers may require more evidence than that provided in a class lecture to change a habit that has been developed over time.

It may also be the case that the intervention used in this study did not effectively enhance drivers' knowledge of their visual limitations at night. Drivers who do not believe that their vision is compromised at night may not realize they need to change their driving behaviors to compensate for this change in vision. Further research is needed to determine what evidence, if any, would be most effective in altering drivers' understanding of their own vision at night. Given the success of previous interventions in changing pedestrians' judgments of nighttime conspicuity (e.g., Balk, Brooks, Klein, & Grygier, 2012; Tyrrell, Patton & Brooks, 2004), an investigation of ways in which to improve the present intervention may prove to be useful to future research in this area. For example, Tyrrell, Patton, and Brooks found that an educational intervention combined with a demonstration of the visibility of pedestrians at night led to an appropriate decrease in pedestrians' estimates of their own conspicuity. A similar manipulation demonstrating the benefits of high beams over low beams, particularly when combined with the educational intervention used in this study, could offer drivers sufficient evidence to change the frequency with which they utilize their high beams.

One potential explanation for the non-significant difference in high beam usage among the three groups relates to a limitation of the intervention. The results of Study 1 indicated that attitude was the best predictor of intentions to use high beams. Ajzen (2011) states that changing the component(s) with the greatest contribution to intentions should ultimately change behavior; therefore, attitude was the focus of the intervention delivered in this study. However, participants in Study 1 reported attitudes toward high beams that were, on average, very positive (M = 6.2 out of 7). Given this, it is possible that there was not room for the educational intervention to improve attitude, therefore making changes in intentions and behavior unlikely. This may explain the lack of significant improvement in high beam usage for the intervention group overall. It is possible that using the intervention to target another component that was not rated as positively but still contributed to intentions (e.g., perceived behavioral control) may have yielded changes in high beam usage.

The participants who formed implementation intentions were not significantly more likely to use their high beams based on both self-report and objective data. This may be due in part to the manner in which participants were asked to form their implementation intentions. Specifically, participants were simply instructed to outline the circumstances under which they planned to use their high beams for the following month, intentionally allowing them to choose the content and length of their implementation intention. However, it is possible that the lack of guidance regarding the content and structure of their intentions may have weakened this manipulation. Indeed, Armitage (2006) suggests that allowing participants to form their own implementation intentions can diminish the usefulness of the intention itself; instead, providing participants with their implementation intention may be a more useful means by which to change a given behavior. The level of specificity of implementation intentions may also influence the effectiveness of implementation intentions. de Vet, Oenema, and Brug (2011) found that participants who formed maximally specific implementation intentions were more physically active than those participants who were less specific in their intentions. The lack of guidance in forming the implementation intentions in the present study may have led to less specific implementation intentions (e.g., "I plan to use my high beams when I am driving as long as there are no other cars around and it's not foggy outside"), ultimately reducing the effect of forming implementation intentions.

The lack of a significant effect of implementation intentions on high beam usage is inconsistent with at least some of the previous research in this area. Several studies (e.g., Armitage, 2006; Browne & Chan, 2012; Orbell, Hodgkins, & Sheeran, 1997) have reported significant changes in behavior after participants formed implementation intentions. However, the findings of this study are consistent with those of Lavin and Groarke (2005), who did not find a significant improvement in flossing behaviors after participants specified when and where they would floss their teeth for three weeks. The authors attributed their findings, in part, to the relatively short period of time during which flossing data were recorded. Lavin and Groarke suggest that a longer period of time may be necessary for some behaviors to be changed by the formation of implementation intentions. Similarly, in the present study, participants self-reported high beam usage for three to four weeks before on-road high beam usage was measured. It is possible that an effect of implementation intentions may have emerged given more time.

Lavin and Groarke also highlight the importance of continuing to study the effect of implementation intentions on behaviors that are potentially performed on a daily basis. Several of the cases in which implementation intentions successfully changed behavior involved behaviors that are measured or reported once (e.g., breast self-exams). It may be the case that implementation intentions are most effect when they serve as a reminder to carry out a task once and are less effective at modifying behavior that may occur repeatedly, such as driving at night and using high beams. This is particularly important given the fact that choosing a beam setting while driving at night is continuous process rather than a single choice or behavior. Future research should explore ways in which a salient reminder (e.g., perhaps a placard in the vehicle in the driver's own handwriting) of a driver's implementation intention influences performance of a behavior (such as high beam usage) over longer periods of time.

While the results of this study indicate that neither implementation intentions nor the educational intervention significantly increased high beam usage relative to that of participants in the control group, drivers in this study used their high beams more often (on average) than drivers in previous studies. Both Hare and Hemion (1968) and Mefford, Flannagan, and Bogard (2006) reported that high beam usage did not exceed 25% even under conditions that would have been ideal (e.g., rural, unlit roads with no traffic) to use high beams. When observing and judging high beam usage of drivers travelling on two lane, rural roadways with no fixed illumination present, Sullivan, Adachi, Mefford, and Flannagan (2003) found that drivers of "clear vehicles" (i.e., no opposing, leading, or following vehicles present) used their high beams approximately half of the time. In the present study, drivers used their high beams 48%, on average, when no leading or oncoming vehicles were present. The route driven included several luminaires and high beam usage in this study still exceeded the rates reported by both Hare and Hemion and Mefford et al. This finding indicates that drivers in the present study used their high beams more often than those in previous studies, though the present findings are consistent with Sullivan et al. (2004), who reported that approximately half of the drivers used their high beams when it was deemed appropriate.

While drivers in this study used their high beams relatively often, there are limitations to drawing this conclusion. While the drivers were not informed of the purpose of the in-vehicle camera prior to the drive, the fact that their driving was being monitored may have encouraged them to engage in “good behavior.” Because the participants were asked to fill out a daily survey about driving behaviors, which included questions about high beam usage, they may have been alerted to the fact that using their high beams would be considered a “good behavior” in this study. During the drive in the second session, two participants (4% of sample) mentioned that they recognized a connection between the daily surveys and the driving portion of the study. This suggests that other participants may also have been aware of the true purpose of the study, artificially inflating high beam usage rates. Similarly, Lavin and Groarke indicated that the diary keeping in that study may have created demand characteristics for participants, thereby influencing participants to behave differently than they might otherwise.

Providing further insight into the increased high beam usage in the present study is the modest correlation between low beam illumination and percentage of appropriate high beam usage. There was a tendency for drivers whose low beams produced lower levels of illumination to use their high beams more often (r = -.23), particularly those drivers who received the intervention (r = -.42). It is possible that the drivers of vehicles with decreased low beam output use their high beams more often to compensate for the relatively poor illumination. An empirical investigation of the effect of decreased low beam illuminance on high beam usage would lend further insight into this relationship, particularly given that previous research suggests that drivers do not notice reductions in headlight illuminance until that reduction exceeds 60% (Rumar, 1974). However, participants in the Rumar study were simply asked about how dirty they thought their headlights were and if they intended to clean them; no measures of driver behavior were recorded. It is possible that smaller reductions in headlight illuminance (i.e., less than 60%) may be sufficient to change driver behaviors such as high beam usage.

Despite its limitations, the present study offers two key benefits in respect to measuring on-road high beam usage. First, these data provide driving researchers with updated data regarding “typical” drivers’ high beam use during an open-road drive. The results of this study indicate that these drivers used their high beams more often than previously reported; further research is needed to confirm this finding. The second benefit of the current research is the method employed to measure high beam usage. This method had high external validity, in that drivers drove an open-road route that was carefully chosen based on several key factors thought to influence high beam usage (e.g., roadway with low traffic volume and a general absence of roadway illumination). This approach allowed for greater control of such factors while also gathering naturalistic driving data. This methodology may be applied to future research investigating not only high beam usage but a variety of driving behaviors (e.g., distracted driving) that may be recorded via video feed from the driver’s perspective.

One goal of this study was to assess the usefulness of the TPB in predicting drivers’ use of high beams. Subjective norm and intentions were revealed to be predictors of this behavior; specifically, drivers with more positive perceptions of subjective norm and intentions were more likely to use high beams. However, given the fact that previous high beam usage also predicted a significant proportion of variance in high beam usage, it is possible that the TPB may not be useful in this context; further research is needed to better understand the predictors of this particular behavior.

A key purpose of the present study was to evaluate the effectiveness of an educational intervention, both alone and combined with implementation intentions, in increasing young drivers' high beam usage. The results of the study indicate that these measures did not significantly change high beam usage relative to drivers in the control group. However, drivers in all groups used their high beams more often than might have been expected based on previous research, though this finding should be interpreted cautiously given the fact that appropriate high beam usage in this study was based on the assumption that other vehicle traffic was absent. However, at least one participant used their high beams even when other vehicles were present, which would indicate potentially inappropriate use of high beams. Further research is needed to accurately quantify appropriate high beam use.

Future researchers should continue to investigate the factors that influence drivers' decision to use (or not use) their high beams and ways in which drivers can be encouraged to develop a more appropriate reliance on their high beams. This area of research will be particularly relevant as more vehicle manufacturers begin to incorporate adaptive headlights (i.e., headlights that change aim and/or modify their output in accordance with traffic conditions as drivers navigate roadways; Fleming, 2012) into vehicles. It will be important to investigate drivers' understanding of the benefits (and limitations) of high beams because this knowledge may influence drivers' trust and use of such technology. For example, drivers who believe that low beams are sufficient for all nighttime conditions may choose to disable an adaptive system that adds light where they believe that light should not be projected. Knowledge of visual limitations at night and how high beams can impact vision may also shape drivers' behavior when using this technology; previous research (e.g., Braitman, McCartt, Zuby, & Singer, 2010) suggests that drivers using adaptive headlights may be more likely to driver faster at night. Further research is needed to understand how educating drivers about the challenges associated with driving at night may impact use of technology such as adaptive headlights and how this relates to driving safely at night.

APPENDICES

Appendix A

TPB questionnaire

Note: From this point on, we will refer to the dimmer/lower headlight setting in your vehicle as **low beam** headlights and the brighter/higher headlight setting as **high beam** headlights.

1. Age: _____
2. Gender: Male or Female
3. Years of driving experience: _____
4. Approximately what percentage of your driving during the last month was done at night?: ______
5. In the past month, during the times that you drove at night and when there was no other traffic near you, approximately what percentage of the time did you use your high beam headlights? _____

When answering the remaining questions, imagine you are driving at night on an unlit road that contains no other traffic and no fog is present.

6. How necessary is using your high beams while driving in this situation?

1	2	3	4	5	6	7
Unnecessary			Neutral			Necessary

7. How useful is using your high beams while driving in this situation?

1	2	3	4	5	6	7
Not useful			Neutral			Useful

8. Using my high beams in this situation would enable me to see better than if I were using my low beams.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

9. Using my high beams in this situation would allow me to see farther ahead on the roadway than if I were using my low beams.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

10. Overall, what is your attitude toward using your high beams in this situation?

1	2	3	4	5	6	7
Very negative			Neutral			Very positive

11. People who care about me (e.g., my parents) would want me to use my high beams in this situation.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

12. People who care about me (e.g., my parents) would _________ of me using my high beams in this situation.

1	2	3	4	5	6	7
Strongly disapprove	Disapprove	Somewhat disapprove	Neutral	Somewhat approve	Approve	Strongly approve

13. People living in neighborhoods would want me to use my high beams as I drove through their neighborhood without other traffic being present.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

14. People living in neighborhoods would ___________ of me using my high beams as I drove through their neighborhood without other traffic being present.

1	2	3	4	5	6	7
Strongly disapprove	Disapprove	Somewhat disapprove	Neutral	Somewhat approve	Approve	Strongly approve

15. When I drive at night and there is clear weather and no other traffic nearby I have complete control over when I use my high beams.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

16. When I drive at night and there is clear weather and no other traffic nearby whether I use my low beams or my high beams is completely my decision.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

17. In the next month, I intend to use my high beams when there is clear weather and no other traffic nearby.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

18. How likely is it that you will use your high beams in the next month when there is clear weather and no other traffic nearby?

1	2	3	4	5	6	7
Very unlikely	Unlikely	Somewhat unlikely	Neutral	Somewhat likely	Likely	Very likely

Appendix B

Themes identified in focus groups by focus group question

Focus Group Question	*Number of Responses*	*Themes Identified*
How well do you think you see (for example, signs, people, animals) when you're driving at night in comparison to how well you see during the day? Are there specific objects and/or hazards that you sometimes have difficulty seeing at night?	16	• Signs are easy to see • Pedestrians and animals are easier to see during the day • See better during the day
In your opinion, what parts of the roadway can you see best with low beams? What about with high beams?	21	Low beams • Directly in front of you • Lines on the road in front of me/to the side • Reflectors and signs High beams • Reflectors • Wider and further view of the road • More of the surroundings/side of the road
Overall, what percentage of the time that you drive at night do you estimate you use low beam headlights? What percentage of the time that you drive at night do you estimate you use high beam headlights?	16	• Low beams: 70-100% • High beams: 0-30%
When driving at night, how bothersome do you find the high beams of other drivers? Does this affect how often you use your high beams?	31	• Find glare distracting, bothersome, annoying, blinding, etc. • Hardly use high beams because glare is annoying to others • Turn off high beams when others are around
What are the advantages of using your high beams when driving at night and there are no oncoming or leading vehicles present? What are the disadvantages?	22	Advantages • See more/better • See farther ahead Disadvantages • There are none • Can't use in fog
What are some factors that encourage you to use your high beams at night when there are no oncoming or leading	27	Encourage • Curvy, unfamiliar, dark roads

vehicles present? What are some factors that prevent you from using your high beams in those situations?		• Areas with deer <u>Prevent</u> • Bad weather (i.e., rain, fog) • Plenty of light on road • Cause glare in residential areas
Can you think of anyone in your life who would want you to use your high beams when there are no oncoming or leading vehicles present? Is there anyone who wouldn't want you to use your high beams under those circumstances?	23	<u>Use</u> • People who care about you • Parents because it's safe • People on road (i.e., pedestrians) <u>Don't use</u> • People in residential areas • No one
What you were taught about using headlights when learning to drive? For example, were you taught when or when not to use certain headlight settings?	13	• Don't use high beams in fog • Wasn't taught anything – learned by "instinct" • Watched family/parents drive • Learned when to turn off high beams – be considerate • Don't think about it
How do your peers and/or parents use their high beams? (e.g., frequency, circumstances)	28	• Use when it's dark and no one is around • Distinguish between urban/lit and rural/unlit areas when deciding when to use • Always use

<u>Appendix C</u>

Daily questionnaire

Clemson email address:

Date:

Did you listen to the radio at any point while driving today? (Yes/no)

Did you have any passengers in your vehicle at any point? (Yes/no)

If yes, indicate the total number of passengers for today.

Did you drive at night (i.e., after sunset but before sunrise)? (Yes/no)

If yes, indicate total length of time:

If you drove at night, did you use your high beam headlights at any point? (Yes/no)

If yes, indicate which (if any) of the following factors influenced your decision to use high beams (check all that apply)

- Because I was driving on a two-lane road

- Because I was driving on a four (or more)-lane road

- Because I was driving on a rural road

- Because I was driving on a interstate

- Because I was driving in a residential area

- Because I was driving in an urban area

- Because I was driving in low traffic density

- Because I was driving in medium traffic density

- Because I was driving in high traffic density

- Because there was no traffic in front of me

- Because no street lights were present

- Because some street lights were present

- Because there was clear weather (i.e., no precipitation)

- Because there was rain

- Because there was fog

-Other: _____________________

Please check each navigational aid you used while driving today:

Smart phone

GPS device

Map

Printed directions

Other

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